Diesel Fuel Comparison Study Workshop

August 14, 2008

California Environmental Protection Agency

Air Resources Board

Agenda

Background
- AB679 (Calderon)
- Legislative Intent

- Project Schedule
- Draft Test Plan Review
  - Objective & Scope
  - Proposed Test Engine/Cycle Selection
  - Proposed Test Vehicle/Cycle Selection
- Diesel Fuel Properties
  - CARB ULSD
  - Federal ULSD
  - EPA Unified Model Results
- Future Discussion Topics
- Next Meeting

Background

- Assembly Bill 679 (Calderon)
  - Requires ARB to convene a panel of interested parties to develop a test protocol
  - Test program shall measure the emissions benefits of CARB diesel fuel
  - Conduct test program
  - Report the results to the Senate Committee on Environmental Quality, the Senate Committee on Transportation and Housing, and the Assembly Committee on Transportation

Background

- Legislative Intent
  - Federal ultralow diesel may produce emissions benefits closer to those of CARB diesel
  - Thought to be especially significant for HD diesel engines employing new technology (e.g. EGR)
  - Higher cost of CARB diesel is a competitive disadvantage for CA trucking industry
  - Develop and implement test plan to measure differences in NOx & PM emissions between CARB diesel and Federal ultralow diesel

Project Schedule

- Contract now in place with UCR CE-CERT for emissions testing
- Draft test plan available for review and comment http://www.arb.ca.gov/fuels/diesel/dieselcomp/dieselcomp.htm
- Review of fuel properties underway, soliciting comments
- Emissions Testing – Scheduled to begin in late 2008
    - Coordinating schedules with Biodiesel Research Program

Draft Test Plan Review

- *Assessment of the Emissions from the Use of California Air Resources Board Qualified Diesel Fuel in Comparison with Federal Diesel Fuels – Overview*

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CE-CERT

Objective & Scope

- Design & implement test program to define the emissions benefits of CARB diesel fuel versus several different Federal diesel fuel blends
  - Proposed scope:
    - Engine dyno – Test 3 engines, multiple test cycles
    - Chassis dyno – 12 to 15 test vehicles, multiple test cycles
    - Fuels – 1 ‘representative’ CARB diesel, 2 Federal diesel ‘blends’
    - Emissions measurements – THC, CO, CO2, NOx, NO, PM

Test Engine Selection - Engine Dynamometer Testing

- Test Engine 1 – Selection Confirmed
  - 2006 Cummins ISM 370, 10.8 liter, EGR
  - EFN: 6CEXH0661MAT
- Test Engine 2 – Selection Confirmed
  - 1991 DDC Series 60, 11.1 liter
  - EFN: MDD11.1FZAZ
- Test Engine 3 – Tentative
  - 2007 DDC MBE4000, 12.8 liter
  - EFN: 7DDXH12.8DJA
  - EGR+OC+PTOX

Test Cycle Selection – Engine Dynamometer

- Recommend using two test cycles
  - First Cycle: Heavy Duty Federal Test Procedure (FTP) Transient Cycle
    - Currently used for emission testing of HDD on-road engines
  - Second Cycle: Propose using 'Translated' test cycle developed as part of the Biodiesel Research Program
    - Would allow comparison of engine dyno results with chassis dyno testing
    - Engine dyno results could be confirmed by chassis testing of in-use HDD fleet
    - Translated Urban Dynamometer Driving Schedule (UDDS)
  - Alternative Second Cycle: ARB Highway HDDT Cycle

Engine Dynamometer Test Matrix

- All emissions tests performed in triplicate
- Replicate baseline tests
- 24 tests per engine

Fuel Type	FTP Transient Test Cycle	Additional Test Cycle
CARB ULSD	3	3
Federal – A	3	3
Federal – B	3	3
CARB ULSD	3	3

Proposed Test Vehicle Selection - Chassis Dynamometer Testing

- Propose testing a matrix of 12 – 15 vehicles
  - Matrix should be based on CA's in-use HD on-road fleet
  - Should incorporate a range of technologies if possible
  - Final matrix to be determined
- Vehicle acquisition
  - Advertisement
  - Rental / lease
  - Private owners
- Resources available for vehicle recruitment

Test Cycle Selection – Chassis Dynamometer

- Recommend using three test cycles
  - First Cycle: Urban Dynamometer Driving Schedule (UDDS)
    - Standard chassis dyno test cycle for HD vehicles
  - Second Cycle: 'Translated' test cycle from Biodiesel Research Study
    - Lightly loaded UDDS, or
    - ARB Highway HDDT Cycle
  - Third Cycle: Central Business District (CBD) bus cycle

Chassis Dynamometer Test Matrix

- 3 - 4 test iterations proposed for all tests
- 9 – 12 tests per vehicle

Fuel Type	UDDS	Test cycle B	Test Cycle C
CARB ULSD	3 - 4	3 - 4	3 - 4
Federal – A	3 - 4	3 - 4	3 - 4
Federal – B	3 - 4	3 - 4	3 - 4

Diesel Fuel Selection

- Propose using three test fuels:
  - Representative or ‘Average’ CARB ULSD
  - Representative or ‘Average’ Federal ULSD
  - Federal ULSD with fuel properties that represent the upper/lower boundaries, affecting emissions characteristics

CARB Diesel Fuel Properties

Average Pool Properties[1]: Summer 2006[2]

Property	CARB ULSD
API Gravity	38.5
Rel Density (60/60°F)	0.8324
T50 (°F)	479.3
Aromatics (v/v)	17.6
Cetane Number (additized)	51.3
Cetane Number (clear)	49.1
Sulfur (ppm)	4.4

[1] All data represent volume weighted averages.

[2] Summer 2006: Refers to the period from June 1 through September 20, 2006.

‘Average’ CARB ULSD Properties
Proposed Ranges for Test Fuel Selection

Property	Range
API Gravity	38 - 39
T50 (℉)	470 – 490
Aromatics (v/v)	16 - 20
Cetane Number (additized)	50 - 54
Sulfur (ppm)	<8

Federal Diesel Fuel Properties

"Alliance of Automobile Manufacturers" North American Fuel Survey"
Summary Statistics for Selected Properties from the Winter 2007 & Summer 2007 Surveys
Note: Statistics are based on data from 18 U.S. cities, including Los Angles

#2 Regular Diesel S15	2007 Winter[1]			2007 Summer[2]		
	min	avg	max	min	avg	max
Rel Density (60/60°F)	0.8217	0.8461	0.8625	0.8169	0.8463	0.8602
T50 (℉)	442	500	551	452	504	548
Aromatics (v/v)	16.8	28.7	38.9	12.1	27.5	40.0
Cetane Number	41.1	42.8	46.7	40.2	46.9	56.6
Sulfur[3] (ppm)	1	6	12	1	6	17

[1] Samples taken in January 2007
[2] Samples taken in July 2007
[3] Using ASTM D5453 on S15 samples only

Federal Diesel Fuel Properties

Northrop Grumman 2007 Diesel Fuel Oils Survey, April 2008
2-D Low Sulfur On-Highway Fuel, Summer 2007

Property	2007 Summer[1]		
	min	avg	max
Gravity, °API	34.1	35.9	39.0
T50 (°F)	476	496	519
Aromatics (v/v)	17.5	28.9	35.3
Cetane Number	42.0	46.5	54.4
Sulfur (ppm)	3	6	8

[1] Based on 17 samples only

Comparison of Federal Diesel Fuel Survey Data

Averages Properties of Samples Collected Summer 2007

Properties	"Alliance of Automobile Manufacturers" North American Fuel Survey Averages[1], Summer 2007	Northrop Grumman 2007 Diesel Fuel Oils Survey, April 2008 Averages[2], Summer 2007
Gravity, °API	35.7	35.9
T50 (°F)	504	496
Aromatics (v/v)	27.5	28.9
Cetane Number	46.9	46.5
Sulfur (ppm)	6	6

[1] Statistics are based on data from 18 U.S cities**, includes 141 samples, 8 from Los Angles, California**

[2] **Statistics are based on data from 17 diesel fuel oils marketed throughout the United States by 4 petroleum refining companies**

‘Average’ Federal ULSD Properties
Proposed Ranges for Test Fuel Selection (Federal – A)

Property	Range
API Gravity	35 - 37
T50 (℉)	490 – 510
Aromatics (v/v)	27 - 33
Cetane Number	44 - 46
Sulfur (ppm)	<15

‘Boundary’ Federal ULSD Properties
Proposed Ranges for Test Fuel Selection (Federal – B)

Property	Range
API Gravity	33 - 34
T50 (℉)	-
Aromatics (v/v)	35 - 40
Cetane Number	40 - 42
Sulfur (ppm)	<15

Results from EPA's Unified Model

Proposed Average CARB ULSD vs. Proposed Federal - A

EPA's Unified Model Results	Default NOx Represents All Engines (g/bhp-hr)	Group L NOx Represents EGR Engines (g/bhp-hr)	Default PM Represents All Engines (g/bhp-hr)
Federal - A ULSD	4.819	2.551	0.150
AVG CARB ULSD	4.578	2.435	0.140
Emission Change	**- 5.0%**	**- 4.2%**	**- 6.5%**

Results from EPA's Unified Model

Proposed Average CARB ULSD vs. Proposed Federal - B

EPA's Unified Model Results	Default NOx Represents All Engines (g/bhp-hr)	Group L NOx Represents EGR Engines (g/bhp-hr)	Default PM Represents All Engines (g/bhp-hr)
Federal - B ULSD	4.975	2.623	0.161
AVG CARB ULSD	4.578	2.435	0.140
Emission Change	**- 8.0%**	**- 7.2%**	**- 12.8%**

Future Discussion Topics

- Soliciting comments regarding range of fuel properties for study test fuels
- Finalize vehicle/engine matrix for emissions testing
- Finalize the selection of appropriate Test cycle(s)
- Continued schedule coordination with Biodiesel research project

Next Meeting

- Tentatively scheduled for October 2008
- Visit our web site
  - http://www.arb.ca.gov/fuels/diesel/dieselcomp/dieselcomp.htm

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